The CHAIRMAN, in opening the business of the evening, said he was sorry to inform the Meeting that their excellent President, Sir Roderick Murchison, was unable to be present owing to the precarious state of Lady Murchison's health. In taking the chair, at the President's request, he felt that Sir Roderick's shoes were too large for him, and that any one who attempted to fill them would go with a shuffling sort of gait. However, he would do his best to supply his absence.

1. *Soundings and Temperatures in the Gulf Stream.* By Commander W. CHIMMO, R.N.

TOWARDS the latter part of the year 1868, after H.M.S. *Gannet* had been upwards of three years on the North American and West India Station, she was ordered during her homeward voyage to define the northern limits of the Gulf Stream, and to take deep soundings and temperatures within those limits.

Sailing from Halifax, in Nova Scotia, on the 1st of July, the ship passed from water whose surface temperature was 51° to that of 61°, in less than an hour, shortly afterwards to 64°; showing that the Gulf Stream water had been reached since leaving that place.

Lat. 43° 20′ N.; long. 60° W.—To the south of Sable Island, 30 miles, a sounding was obtained of 2600 fathoms or 15,600 feet, nearly 3 miles; with a weight of 232 lbs., and the ingenious machine invented by Brooke, the rod brought up, after four hours' patient hauling, Foraminifera in their various forms, chiefly Globigerinæ. Forms and clusters of three, four, and five chambers; the interior of those fully developed was coated with an apparently fine crystallised, many-coloured, quartzose sand—of these forms some were circular—flat and plate-shaped, having a smooth interior rim (the Polycystina); the outer margin serrated, and the centre coated with the same granular particles. Others hemispherical, some single, globular; others, fragments as thin and transparent as water; intermixed with these were particles of transparent many-coloured crystals, with coccospheres in all stages of growth and size.

The towing-net collected seven species of Crustacea, one Cornucopia, and a Janthina fragilis; the dye from which latter, when placed in a wineglass of clear water, coloured the whole a rich mauve. A very small portion of this apparently impalpable adhesive mud, diluted, and placed under the microscope, showed a field of the most perfectly-formed organisms.

The ship next sailed to the western edge of the Grand Banks of Newfoundland, where a sounding of 1500 fathoms brought up what appeared, under a common glass, minute particles of transparent quartzose sand, with globular forms of calcareous formation; also some algæ with parasitical attachments, probably of lime, but all formed by animal life out of carbonate of lime from ocean waters.

The temperature of this mud or "Oaze," as it will be called, was 56°; but at a depth of 1000 fathoms the thermometer showed 40°·3, and at 500 fathoms only 39°·5, so that the mud probably changed its temperature in passing through a stratum of warmer water, as the sea-surface was 60°. This showed an under stratum of very cold water; there being a difference of 20° between the surface and 500 fathoms, and possibly so at a very much less depth.

Having run north of the limit of the Gulf Stream, again stood to the southward, and soon came into warmer water, at a temperature of 60°; from a cold, damp, penetrating fog, into a mild and summer-like atmosphere; 1500 fathoms was again found, and the cup brought up the usual grey impalpable mud (oaze). The towing-net collected a beautiful float of the Nautilus, having 13 chambers, and a fragmentary valve of a delicate fluted Pecten.

The temperatures were precisely the same as in the former sounding, except that the surface was 65°, and at 100 fathoms the thermometer showed 50°; a difference of 15° in only 100 fathoms—another proof of the Gulf Stream being merely superficial.

At day-dawn this morning, to the great surprise of every one, we saw an old Labrador friend, a huge iceberg, having a warm bath in a temperature of 62°, double that of its own. Although it was still 150 feet high, and nearly 400 immersed, it was quickly and perceptibly undermining, decomposing, splitting with loud reports, and floating away in large portions with the easterly current.

It curiously happened that this immense iceberg stood in the very spot 30 miles south of the edge of the Grand Bank, where not only the deepest waters of the Atlantic were supposed to be, but where we intended to get a sounding to ascertain if this were the fact: the result showed it was not so.

Sail was furled, steam got up, and the *Gannet* ranged up as near as was prudent under the lee of our chilly friend; and in the midst of a thunder storm, with Brookes' rod and weights, obtained at a depth of 1450 fathoms the same "Oaze," disproving the idea of the deepest water being here. This depth appears to be not only the usual one, but also the slope of the Banks, as well as the general character of their formation.

By the temperatures here obtained, the same stratum of cold arctic water was passing under the warmer waters of the Gulf Stream. The rod brought up a small portion of feldspar with glittering particles of mica, evidently deposited there by icebergs from Davis Strait, and that very recently.

We now sailed east for the spot where Lieut. Sainthill, in lat. 42° 37′ N. and long. 41° 45′ W., obtained, in 1832, 100 fathoms on

sharp rocky bottom, bringing up on the arming of the lead "fine bluish ashes;" and he was under the impression that he was over a submarine volcano in a state of eruption. At 2 P.M. on the 12th of July we reached this position, and with a heavy weight 4300 fathoms of line ran out, and no bottom!

It was somewhat remarkable that about this place, within a radius of some few miles, many indications of shoal water had been from time to time seen and reported, one having as little as 35 fathoms on it. To one of these, called the "Milne Bank," with only 80 fathoms on it, we were now steering. It had been found by H.M.S. *Nile*, in 1864, on her homeward-bound voyage; and, under most favourable circumstances, soundings of 80, 90, and 100 fathoms, "fine sand and oaze" brought up.

Also, about this vicinity, the currents are found very strong, and a little further east very variable in direction; sometimes running with a velocity of 2, 3, and even 4 miles an hour to the eastward, and in some places forming a complete "race." If neither banks nor shoal-water exist here, it is not easy to account for this additional effort of the Gulf Stream; unless, indeed, it is the mass of water brought from the South Atlantic by the south-east trades, adding to its volume and to its velocity.

Lat. 43° 30′ N.; long. 38° 50′ W.—At 4 P.M., on the 15th of July, we were on the 80 fathoms! The rod and weight of 230 lbs. let go, and as each 100 fathoms ran off the reel it caused some excitement, as at each fathom it was hoped the Bank would be struck. 2280 fathoms, 13,680 feet ran out. There was no bank there. The rod brought up "oaze" abounding in animal, vegetable, and mineral!

Here the thermometers were sent down to ascertain specially if cold water existed at any depth. One thermometer burst at 1400 fathoms. Water was brought up from a depth of 1500 fathoms,* containing small and delicate particles of algæ of various bright colours, showing, probably, that light had penetrated to that depth; but there was not a sign of animal life.†

Another sounding for the Bank was tried, and 2600 fathoms obtained; the rod bringing up from the same vast cemetery countless

---

* Temperature 42°.

† The temperature of the air was 77°
" " " sea " 73°
At 100 fathoms below it was 62° = 10 degrees less
At 300 " " 55° = 20 "
And at 1000 " " 42° or 30 "
so that cold Polar waters were passing underneath at 200 fathoms below the surface.

thousands of its dead, and of the same character as those found a day or two previous at a nearly similar depth, except that the Globigerinæ were in clusters, and in those *fractured* there was a hard, compact, crystallised, fine sand.

The fractured Globigerinæ in this sounding were very beautiful, showing margins of vertical crystal formation, clear as water, the fractured globes or cells containing (apparently) minute quartzose sand. Thinner glass-like forms of air-like globules, in irregular order, were probably Coccospheres.

A small convex portion illustrated beautifully the radiating perforations or canals of the Foraminifer, both direct and diagonal; and some few irregular particles of diatoms flexible and multiform.

One young Globigerina, in which the cells were quite transparent and thin, none of these have any granular deposits in their interior.

Some of these also show the horizontal layers of each wall, added layer to layer—the outer ones thickening, and the external layer becoming coated with tubercules; the interior are of an enamel transparent smoothness.

The heat in the Gulf Stream was found at times very oppressive, and reminded us all of the climate of Trinidad in the wet season. The thermometer in the shade was 82°, in the sun 96°; the warm vapour arising from the heated water made one feel languid, lazy, and sleepy, and was very debilitating.

By the temperatures obtained from actual observation at 300, 500, and 1000 fathoms, the waters were in all cases warmer than the corresponding depths north of the Gulf Stream. This is, of course, very natural, but it is as well to have it from actual observation; and this would argue in favour of bodies of warm water being brought up from the coast of Africa by the south-east trades, from the coast of Spain by the E.N.E. trades, and, accumulating with those of the Gulf Stream on the position assigned to the Milne Bank, assisting materially in adding to its velocity there.

Stood north again for Polar waters, which were soon felt by the temperature of the sea-surface changing in 2½ hours 14°—from 72° to 58°,—giving again the northern limits of the Gulf Stream. The air also gave proofs of this again, for in an hour we passed from a close uncomfortable heat to a chilly cold, which compelled all hands to put on warm jackets; and, as a natural consequence of this change, soon followed a dense fog!

Ran for the Flemish Cap, on which we sounded and obtained 80 fathoms. Stones, feldspar, and various coloured quartz, with some few Foraminiferæ even in these shoal waters.

Sounded midway between the north part of the Flemish Cap and the Grand Bank, to ascertain if there were any connection, or if they were separated by a deep channel. 250 fathoms was obtained, showing that it *was* part of the bank, but having a rocky nucleus, about which the soil brought down by the ice accumulates; but the Polar current over it is sufficiently strong to keep the rock bare. On two occasions it bent and turned the iron cup of the weight in 90 fathoms; here at 250 fathoms the temperature of the sea was 38°, while at the surface it was 50°, the air being the same. The south part of the Cap is not, however, united to the Banks for 700 fathoms, and no ground was obtained between them.

Lat. 46°.—On the parallel of 46° latitude, at a distance of 25 miles from the edge of the bank, sounded in 1000 fathoms, bringing up large quantities of rounded particles of quartz of various colours.

Here a section of the slope of the bank was made, showing its ascent, formation, and the nature of these vast banks. From 1000 fathoms—of coloured, quartzose sand, to 650—of silicious spicules of sponges; then to 450—green mud, 150—quartzose sand, 60—stones, 55—stones, sand, and fish-bones, and the latter told us that we were on the Grand Banks.

Passing over and searching for the "Jesse Ryder Shoal" of 4 fathoms, which was found *not* to exist, we put over the dredge and dropped on a perfect colony of star-fish (Ophiocoma) of all sizes, from half an inch to 3 inches in diameter,

In a very dense fog steered for St. John's, Newfoundland, where we arrived on the 24th July to rest for a few days after the work in the Gulf Stream. It was cold, raw, and foggy; but we were very glad to drop anchor in its snug and secure harbour, free for a while from all the cares, anxieties, and perplexities necessarily attending deep-sea sounding.

Having again prepared lines, instruments, and chronometers for a second voyage, sailed on the 27th August for the north extreme of the Gulf Stream, and which was reached two days afterwards—the sea temperature rising suddenly from 53° to 61°.

Lat. 44° 3′ N.; long. 48° 7′ W.—Here soundings were again obtained with rod and heavy detaching weights in 1650 fathoms, bringing up Foraminiferæ in all stages, whole and fragmentary, having from two to six cells or chambers in clusters, spherical, plate and flat-shaped Polycystina (diatoms), with a few spicules of sponges, as well as some coccoliths.

Temperatures of under strata of currents were obtained, again showing that at 1000 fathoms the water was 39° 5′, and at only 50 fathoms below the surface (which was 61°) it was 43°, or 18°

colder!—air being 61°: another proof of the bare superficial Gulf Stream.

Another cast of the lead on the supposed position of the Sainthill volcano quite disproved the existence of this vigia within a radius of many miles.

We were approaching for the second time the Milne Bank, of 80 fathoms; and although 2300 fathoms was obtained on it a short time since, yet there was still a hope that the second attempt would be more successful, particularly as a telegram had reached me from England to the effect that "there was no doubt of the Milne Bank, as bottom was brought up *three* times;" and indeed so it would appear. But on the 3rd of September (lat. 43° 40′ N., long. 38° 50′ W.) the lead was again let go and 2700 fathoms obtained, the rod bringing up a small but precious particle of Foraminifera.

The towing-net gave another rich haul of Hyalæa—Atlanta and Spirula—with three specimens of Nautilus cornucopia (I believe the latter to be Operculate). In no case could the remains of those creatures which had lived on the surface be found in the vast cemetery at the bottom; probably long before they reached so great a depth their softer parts had decomposed and their shells assisted in forming one of the component parts of the ocean, carbonáte of lime, or became food for their hungry neighbours the Mollusks.*

It is curious to find how the different species of these delicate ocean-shells have their own special haunts and feeding-grounds. In one place the Atlanta are taken in numbers, with scarcely any others; in another a net full of Hyalæa tridentata; then quantities of Spinosa or Radiata; lastly, a bag of Jauthina fragilis; but these latter are more generally distributed than others. All these are found more numerous on the surface at the sun's rising and setting, and very abundant during light showers of rain.

Near the supposed position of this bank we sounded at short distances for some days with more than a thousand fathoms of line: but in no case was there any indication of this bank. The last effort to sound in 1000 fathoms north of this supposed bank will not easily be forgotten; it was obtained under many and great difficulties. The sea had risen to a fearful height in a very short time, which threatened to roll all the boats from the davits. My steam-cutter *Torch* did start. There was scarcely any standing on the deck. All the thirty-five men on the starboard side, while hauling the line in, lay down, or rather were thrown down on the line.

* Towards the end of these investigations I was compelled to alter my opinion on this subject, an interesting sounding having brought up from 2000 fathoms the shells of those Pteropods living on its surface.—W. C.

Lat. 43° 30′ N.; long. 38° 5′ W.—Sounded again with heavy weights in 2000 fathoms, bringing up Foraminiferæ in varions stages of growth; and what gave interest and value to this sounding, was the fact that icebergs had reached these limits, proved by the presence of a piece of stone, three-quarters of an inch in size, deposited undoubtedly there by a berg, and brought up in the valve.

Lat. 43° 43′ N.; long. 37° 47′ W.—On the 5th of September a sounding was taken at 1930 fathoms; the rod came up with its spring broken, but retaining sufficient of the bottom to show that it was down. Foraminiferæ, the usual deep-sea characteristic, appeared, mostly young and small, with transparent cells: about 6 per cent. of all these are free from fracture, all the remainder fragments.

Before leaving the vicinity of this supposed bank, the temperatures here obtained with new and delicate thermometers at 2000 fathoms was 42°—rather a higher temperature than expected. The air was 68°; the sea-surface 69°; while at 100 fathoms it had fallen 10°, and at 400 20°! At 1000 fathoms it was 43°, after which it fell but 1° in 1000 fathoms.*

Great quantities of Salpæ and Medusæ came up entangled with the line, doubtless caught in its quick descent of 500 fathoms in 3½ minutes.† Their orange-coloured stomachs, situated in the centre of the transparent gelatinous sacs, came in quite perfect on the line.

Lat. 43° 39′ N.; long. 36° 46′ W.—On the 6th September we gave our departing and final cast of the lead in this vicinity, getting 2060 fathoms; the rod bringing up Foraminiferæ, small stones, and some Diatoms.

We were now leaving the regions of the Globigerinæ and Lime formations, changing them for those of Silicious deposit. Nearly all in this last sounding were Diatoms, with but few Globigerinæ. A thermometer was sent down to 2000 fathoms and proved the last temperature at the same depth, showing 42°·5.

To complete a series of 100-fathom temperatures, advantage was taken of a fine day with smooth water—both indispensable requisites in sounding for temperatures, as the smallest jerk or vibration moves the indices and the reading is destroyed, the results being only deceptive. The thermometer went down to 1500 fathoms, and in no instance did it show less than 42°·5, fully proving the high temperatures obtained on former occasions, and this would prove the entire absence of an under Polar current here; and further, that the waters of the Gulf Stream here mixed with other waters, decreasing

* Showing a great uniformity of temperature after the first 500 fathoms.
† Or equal 14 feet in 1 second, which equals 1 mile in 6 minutes.

thereby its strong easterly set, which was here found on many occasions to be variable. The temperature of the surface was 71°.

From the authority of a few scattered observations, it has been asserted that the water of the ocean, at a depth of 12 feet, was of a higher temperature than at the surface. This was proved to be correct, although remarkable, by 45 carefully-obtained observations between Halifax and this position.

Of these 45 observations, 26 are warmer, 10 are colder, and 9 have the same temperature. The warmer are in favour of the colder, 16° in the whole, but in no one instance greater than 1°·5; and the greatest and most constant are noticeable to the east of the Milne Bank, after the rapid current of the Gulf Stream had been passed.

In the Pacific, off the west coast of America (the Isalcos Mountains), the temperature at 12 or 15 feet below the surface has been found to be 10° or 11° higher. This, I presume, is caused simply by excessive evaporation, as I have often found there the difference between the wet- and dry-bulb hygrometer to be 9°, and on one occasion 11°.

Lat. 46° N.; long. 29° 40′ W.—9th of September, being on the position of a vigia, a very satisfactory sounding of 1650 fathoms was obtained: first disproving the existence of such a danger, and secondly bringing up the most interesting and remarkable specimen of the bottom; showing that those minute creatures which live on the surface do assist in forming the bottom of the ocean. Foraminiferæ and Diatomacæ surrounding six dead Hyalæa shells, all perfect. These, to have been taken on the bottom, must have been dead, and for a valve the size of a shilling to have entrapped six of these, they must have been numerous indeed; the whole area of the six was greater than the valve itself—they must, therefore, have been in such quantities as to overlap one another. Hyalæa were also taken on the surface in the towing-net; so that here was a successful illustration that these lived on the surface and were buried after their period of existence on the bottom.

This was a shoal-sounding compared with those around it, and silicious animal formations now became more numerous; the Coccospheres and other delicate forms exactly resembling the Nautilus, chambered, but devoid of the syphuncle by which the latter elevates and depresses itself at pleasure, by exhausting or filling its chambers with water. Thirteen chambers were counted in one form.

In this sounding, also, animal remains were seen, and could hardly be mistaken; the feelers or radiating processes from the tubercles of the canals were regularly radiating, and at the point where the chambers intersect was a mass of minute spawn-like globules.

Inorganic fragments of some size were also seen, having a smooth concave impression, intersected with dark lines. In no instance are the shells of the Hyalæa, taken alive on the surface, so large as those found dead on the bottom; so that it may be possibly inferred that they have died at their full growth, at the limit of their permitted existence.

A very interesting and valuable sounding was made about 180 miles E.N.E. of the last, in 1180 fathoms, showing a less depth of water by 200 fathoms than in any part of the Atlantic (not approximate to the shore). A small portion of the bottom "Oaze" came up attached to a pig of ballast, which was the weight used on this occasion.

Lat. 47° 11′ N.; long. 23° 14′ W.—On the 12th September the favourable weather, with a dead calm, induced us to sound, and a cup-lead of 112 lbs. reached the bottom at 2000 fathoms, bringing up a full cup of pale cream-colour "Oaze," Infusoria, like ice-cream, and quite as cold. In this sounding were many-shaped and various-formed Globigerinæ, hemispherical and globular; also many spheroidal organisms, in one specimen of which we counted thirteen chambers.

A fractured portion of a Globigerina cell showed that the interior wall was formed of perpendicular transparent four-sided cells, while the exterior was perforated by narrow canals running perpendicular to the frame. The temperature at that depth was still 42°.

Our sounding had now ceased, and this novel and interesting work had finished.

It is worthy of remark that the general character of all these thirteen soundings, varying in depth from 80 to 2700 fathoms, spreading over an area of upwards of 10,000 square miles from Sable Island to the Azores, shows a remarkable uniformity both in respect of temperature and sea-bottom. One chief object throughout was to ascertain if in any of these organised forms animal life still existed. They were placed for fourteen days under a powerful microscope, and in no one instance was either animal life or animal remains visible except in the two doubtful instances recorded. Therefore it may be safely concluded that these minute creatures do not live where found, at the bottom of the ocean.

Hundreds of the animal organisms of Foraminiferæ, Globigerinæ, Coccoliths, &c., with which the soft light brown and yellow mud abounded, were, after being diluted with clear water, separated from the muddy particles and broken under the lens with a finely-pointed penknife. It required some force to break them, and the sharp

shock and cracking was plainly perceptible; in no single instance was life or movement visible.

The mud, when dry, is either of a pale yellow marl, light brown, or greenish-brown colour; the former containing chiefly Globigerinæ or calcareous formations, the second Silicious or Diatomaceæ, and the last silicious spicules of sponges. All are apparently soft mud until rubbed between the fingers, when gritty particles are detected. These are the Globigerinæ in great variety of shapes and numbers, some being formed in concentric layers round a transparent centre.

In the deepest waters and most distant from land were the greatest numbers of perfect specimens of the Globigerinæ found, in soundings 12 and 13; and as the water decreased in depth and neared irregularities, so they became fragmentary. These facts suggest that, either at the lesser depth some wave-movement, or, may be, current, fractured these delicate organisms, or that their cases were broken by mollusks or other devouring agents for the softer matter in the interior, and the shelly portions then allowed to descend to the bottom.

With many experiments in water, it was found that not only were the Globigerinæ of much more specific gravity than the water, but that they sank with a rapidity truly wonderful and invariably with the convex side downward, and in that position (which was contrary to which they lived) remained so.

In passing the soundings a second time under the microscope, some new forms were detected, which will be seen in the drawings, and these are for the most part of silicious formation, some having a thin, irregular, and broken coating of lime; others as transparent as glass.

The thin membrane-lining in some of the Globigerinæ were also noticed, but these could hardly be the remains of the once-living animal.

Some recent Globigerinæ, which appeared discoloured (a light red), were broken; but no minute granules were inside.

In the second examination of the Globigerinæ I was compelled to alter my views with regard to the rounded aperture (which I thought may be formed by an annelid), but which I found in every form, larger or smaller, according to age and size. In some instances the apertures were in the *two* last chambers, the lips of which were smooth and rounded off with a transparent glass-like finish.